A COMPOSITE INSULTING ADHESIVE TAPE

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a composite insulating adhesive tape. More particularly, the present invention relates to a flexible composite insulating adhesive tape that can be used to prevent electro-magnetic wave interference (EMI) effects, the tape having superior flexibility and tearing characteristics.

2. Description of the Prior Art

In daily life, insulting adhesive tapes are widely used to cover electrical apparatuses or electric wires, such as transformers, capacitors, fixture wires, motor lead wires, degaussing coils, telephone wires and other communication wires, etc. These tapes provide insulation to the devices, which they cover. Superior buckling resistance, conformity and flexibility are important characteristics of these insulting adhesive tapes to prevent insulation failure or short-circuiting caused by physical impact or sloppy wrapping of the electrical apparatuses or electric wires. Insulting adhesive tapes are also important for protecting users from electric shock.

Insulating adhesive tapes must be able to withstand severe conditions, such as high voltages, strong electric fields, strong magnetic fields, moisture, ultraviolet light, heat, etc. Accordingly, superior voltage resistance, heat resistance, flame resistance, chemical and water resistance are all required for these tapes.

Most of the prior art flexible insulating adhesive tapes that achieve the above-mentioned properties are composed of vinyl halide

resins, such as, polyvinyl chloride (PVC), chlorinated polyethylene (CPE) and chlorosulfonated polyethylene (CSPE). PVC is most commonly used when manufacturing an insulating tape owing to its superior flexibility and conformity characteristics, and also because it is inexpensive. Many studies have revealed that polyethylene terephthalate (PET) is also a good insulating material. However, due to its inferior flexibility, PET is not commonly used in the insulating tape industry.

Many researches have reported that halogen contained polymers, such as PVC, decompose during waste incinerating processes, producing hydrochloric acid. This not only corrodes the walls of the incinerator, but is also a source of acid rain. Also, plasticizers, such as dioctyl phthalate (DOP), which are generally used in PVC related plastic products, are hazardous. In addition, polychlorinated biphenyls (PCB), a toxic and non-degradable compound, is formed when PVC reacts with benzene-containing compounds at relatively high temperatures. In order to enhance the stability of a PVC insulating tape, certain heavy metals, such as lead, lead phthalate, lead phosphite, lead sulfate, cadmium or calcium metal compounds are added during the manufacturing process of the PVC insulating tape. These heavy metals can cause serious environmental pollution and affect human health. Fortunately, in the last few years, limitations have been enacted to prohibit these heavy metals from being used in PVC insulating tapes.

Accordingly, using nontoxic materials, such as fiberglass or PET, has become the norm in the insulating tape industry. One approach is disclosed in U.S.PAT.4868035 in which PET films, in combination with fiberglass, are used to form an insulating tape with superior electrical insulation properties. However, insulating tapes made of PET films and fiberglass are expensive, and have poor flexibility, conformity and tearing characteristics. Consequently, the range of

applications of PET films is limited.

It should be noted that the prior art insulating tapes are generally poor at shielding against electro-magnetic wave interference (EMI). Thus, the prior art method for preventing EMI is to wrap several layers of foil around an insulating tape that has adhered to an electrically conductive object. However, the prior art method for preventing EMI effects is unable to completely and smoothly cover the electrically conductive object. Additionally, it is easy for the foil to fall off, leading to a reduction of EMI insulation properties.

SUMMARY OF THE INVENTION

It is therefore a primary objective of this invention to provide an inexpensive, nontoxic insulating adhesive tape. The composite insulating adhesive tape according to the present invention has superior flexibility, conformity, tearing and voltage resistance characteristics.

In a preferred embodiment, the present invention method involves using an unhalogenated material with superior insulation properties to form a composite insulating adhesive tape. Basically, the composite insulating tape comprises an embossed reinforcing polymer layer, a first flexible layer and an adhesive layer. The embossed reinforcing polymer layer comprises a top face and a bottom face. The first flexible layer is formed on the top face of the embossed reinforcing polymer layer to improve the flexibility and conformity of the composite insulating adhesive tape, while the adhesive layer is formed on the bottom face to enable the insulating adhesive tape to be adhered to an object. The method of forming the embossed reinforcing polymer layer has been clearly disclosed in

U.S.PAT.5853138. The first flexible layer is composed of a material with a draw ratio at 20℃ that is below 400%. The embossed reinforcing polymer layer is first impressed using an impressing process that is used to form a plurality of pores randomly distributed throughout the embossed reinforcing polymer layer. These pores enhance the flexibility of the embossed reinforcing polymer layer.

Furthermore, in order to increase both the flexibility and the thickness of the insulating adhesive tape, a second flexible layer is coated over or between the embossed reinforcing polymer layer and the first flexible layer. Furthermore, in order to prevent electro-magnetic wave interference (EMI) effects, the insulating adhesive tape can further comprise an electrically conductive layer.

It is an advantage of the present invention that the composite insulating adhesive tape is halogen-free, and the flexibility of the composite insulating adhesive tape is significantly enhanced. In addition, the present invention requires fewer materials, leading to lower manufacturing costs.

These and other objectives of the present invention will no doubt become obvious to those of ordinary skill in the art after reading the following detailed description of the preferred embodiment, which is illustrated in the various figures and drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig.1 is a cross-sectional diagram of a composite insulating adhesive tape of the preferred embodiment according to present invention.

Fig.2 is a cross-sectional diagram of a composite insulating adhesive tape of the second embodiment according to present

invention.

Fig.3 is a cross-sectional diagram of a composite insulating adhesive tape of the third embodiment according to present invention.

Fig.4 is a cross-sectional diagram of a composite insulating adhesive tape of the fourth embodiment according to present invention.

Fig.5 is a cross-sectional diagram of a composite insulating adhesive tape of the fifth embodiment according to present invention.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Please refer to Fig.1. Fig.1 is a cross-sectional diagram of a composite insulating adhesive tape 10 of the preferred embodiment according to present invention. As shown in Fig.1, the composite insulating adhesive tape 10, with a thickness of 25 μm to 250 μm, comprises an embossed reinforcing polymer layer 12, a first flexible layer 14, an adhesive layer 16 and a release layer 18. The embossed reinforcing polymer layer 12, with a thickness of 5 μm to 150 μm, comprises a top face 11 and a bottom face 13. The first flexible layer 14, with a thickness of 10 μm to 150 μm, covers the top face 11 of the embossed reinforcing polymer layer 12 and is used to improve the flexibility of the insulating adhesive tape 10. The adhesive layer 16, with a thickness of 10 μm to 100 μm, covers the bottom face 13 of the embossed reinforcing polymer layer 12 and is used to adhere the composite insulating adhesive tape 10 to an object. The release layer 18 that is adjacent to the adhesive layer 16 is used to maintain the adhesion feature of the adhesive layer 16.

The embossed reinforcing polymer layer 12 is composed of unhalogenated polymer materials. The unhalogenated polymer materials could include poly(ethylene terephthalate) (PET), polyethylene naphthalate (PEN), polypropylene (PP), or polyimide (PI). The first

flexible layer 14 is composed of flexible polymer materials with relatively low glass transition temperature properties; for example, polyethylene (PE), acrylic, polyurethane resin (PU resin), ethylene vinyl acetate (EVA), or Surlyn™. Above the glass transition temperature, a highly crystalline polymer becomes flexible and moldable, i.e. thermoplastic. PE is recommended as a starting material of choice for the first flexible layer 14, and the draw ratio of the first flexible layer 14 at 20℃ should be below 400%.

The materials used for the adhesive layer 18 could include acrylic adhesives, polyurethane adhesives, rubber adhesives, hot melt adhesives, silicone adhesives, etc. To enhance the adhesion of the adhesive layer 18 to the embossed reinforcing polymer layer 12, adhesion promoters, such as coupling agents, chelates or crosslinking agents, can be added. The type of promoter used will depend on the materials involved. Components of the adhesion promoter can comprise silane compounds, titanates, aluminates, boric acid esters, zirconium aluminates, etc. The adhesion promoter can be applied directly to the embossed reinforcing polymer layer 12 instead of being added directly to the adhesive layer 16.

The method of making the composite insulating adhesive tape 10 is now discussed. Initially, a die extrusion curtain coating process is performed to evenly form the first flexible layer 14 on the top face 11 of the embossed reinforcing polymer layer 12. During the die extrusion curtain coating process, PE is melted and evenly coated onto the top face 11 of the embossed reinforcing polymer layer 12, using a T-die extrusion curtain coating technique, to form a thin, melted PE film. When the thin, melted PE film cools, the first flexible layer 14 complete. By virtue of the die extrusion curtain coating process, the first flexible layer 14 and the embossed reinforcing polymer layer 12 tightly cohere to each other, forming a composite

film that possesses superior flexibility properties. The embossed reinforcing polymer layer 12 is impressed using an impressing process to form a plurality of pores that are randomly distributed throughout the embossed reinforcing polymer layer 12 so as to enhance the flexibility and tearing characteristics of the insulating adhesive tape 10.

In order to improve the affinity of the top face 11 of the embossed reinforcing polymer layer 12 for the first flexible layer 14, a surface pretreatment process, using a corona discharge technique, a flame burning technique, or a primer, is performed after the impressing process.

Please refer to Fig.2, which depicts an alternative cross-sectional structure of a composite insulating adhesive tape 20 according to present invention. As shown in Fig.2, the composite insulating adhesive tape 20 comprises an embossed reinforcing polymer layer 22, a first flexible layer 24, an adhesive layer 26 and a release agent coating 29. The embossed reinforcing polymer layer 22 has two faces: top face 21 and bottom face 23. The first flexible layer 24 covers the top face 21 of the embossed reinforcing polymer layer 22 to improve the flexibility of the composite insulating adhesive tape 20. The adhesive layer 26 that is used to adhere the composite insulating adhesive tape 20 to an object covers the bottom face 23 of the embossed reinforcing polymer layer 22. The embossed reinforcing polymer layer 22 is impressed using an impressing process to form a plurality of pores that are randomly distributed throughout the embossed reinforcing polymer layer 22 so as to enhance the flexibility and tearing characteristics of the insulating adhesive tape 20.

The release agent coating 29 is coated over the first flexible

layer 24. When the insulating adhesive tape is rolled up, the adhesive layer 26 of the insulating adhesive tape 20 will be adjacent to the release agent coating 29.

Please refer to Fig.3. Fig.3 is a cross-sectional diagram of a composite insulating adhesive tape 30 of the third embodiment of the present invention. As shown in Fig.3, the composite insulating adhesive tape 30 comprises an embossed reinforcing polymer layer 32, a first flexible layer 34, an adhesive layer 36, a second flexible layer 35 and a release liner 38. Also, the embossed reinforcing polymer layer 32 has two faces: top face 31 and bottom face 33. The first flexible layer 34 and the second flexible layer 35 respectively cover the top face 31 and the bottom face 33 of the embossed reinforcing polymer layer 32 to improve the flexibility of the composite insulating adhesive tape 30. The adhesive layer 36 that is used to adhere the composite insulating adhesive tape 30 to an object is formed on the surface of the second flexible layer 35. The embossed reinforcing polymer layer 32, the first flexible layer 34 and the second flexible layer 35 together form a composite polymeric insulating film 37.

The only difference between the composite insulating adhesive tape 30 in this embodiment and the composite insulating adhesive tape 10 depicted in Fig.1 is that the composite insulating adhesive tape 30 comprises the second flexible layer 35. The second flexible layer 35 is used to increase both the flexibility and the thickness of the composite insulating adhesive tape 30. Depending on the desired results, the second flexible layer 35 may be formed using different flexible polymer materials, such as PE, acrylic, PU resin, EVA, or Surlyn™ with different thicknesses. PE is recommended as the polymer material of choice for the second flexible layer 35 because of its low cost and high flexibility properties.

Similarly, the embossed reinforcing polymer layer 32 is previously impressed using an impressing process to form a plurality of pores that are randomly distributed throughout the embossed reinforcing polymer layer 32 so as to enhance the flexibility and tearing characteristics of the insulating adhesive tape 30. In one case, the first flexible layer 34 and the embossed reinforcing polymer layer 32 are impressed using the impressing process to form a plurality of pores that are randomly distributed throughout both the first flexible layer 34 and the embossed reinforcing polymer layer 32 so as to enhance the flexibility of the insulating adhesive tape 30. In another case, the second flexible layer 35 and the embossed reinforcing polymer layer 32 are impressed using the impressing process to form a plurality of pores that are randomly distributed throughout both the second flexible layer 35 and the embossed reinforcing polymer layer 32.

In order to protect the adhesive layer 36, the release layer 38 is used and next to the adhesion layer. The release layer 38 can comprise paper liner or film liner. The release layer 38 is peeled away when one wishes to expose the adhesive layer 36 to stick the composite insulating adhesive tape 30 onto a surface of an object.

Please refer to Fig.4. Fig.4 is a cross-sectional diagram of a present invention composite insulating adhesive tape 40 that is able to prevent EMI effects. As shown in Fig.4, the composite insulating adhesive tape 40 comprises an embossed reinforcing polymer layer 42, a first flexible layer 44, an adhesive layer 46, a release liner 48 and a composite metallic layer 80. The embossed reinforcing polymer layer 42 has two faces: a top face 41 and a bottom face 43. The first flexible layer 44 covers the top face 41 of the embossed reinforcing polymer layer 42. The adhesive layer 46 is formed on the bottom face

43. As noted, the release layer 48, that can later be peeled away, is used to protect the adhesive layer 36. The insulating adhesive tape 40 has a thickness of 50μm to 200μm, with a preferred thickness of 75μm to 150μm.

Before the first flexible layer 44 is formed on the top face 41 of the embossed reinforcing polymer layer 42, the embossed reinforcing polymer layer 42 is previously impressed using an impressing process. A die extrusion curtain coating process is then performed to evenly form the first flexible layer 44 on the top face 41 of the embossed reinforcing polymer layer 42. In one case, the first flexible layer 44 and the embossed reinforcing polymer layer 42 are both impressed using the impressing process to form a plurality of pores that are randomly distributed throughout both the first flexible layer 44 and the embossed reinforcing polymer layer 42 so as to enhance the flexibility of the insulating adhesive tape 40.

The only difference between the composite insulating adhesive tape 40 in this embodiment and the composite insulating adhesive tape 10 depicted in Fig.1 is that the composite insulating adhesive tape 40 comprises the composite metallic layer 80 that enables the composite insulating adhesive tape 40 to shield against EMI effects. The composite metallic layer 80 comprises an aluminum electrically conductive layer 85, a polymer layer 83 formed on the bottom surface of the aluminum electrically conductive layer 85, and an adhesive layer 81 formed on the bottom surface of the polymer layer 83. The adhesive layer 81 is used to adhere the composite metallic layer 80 to the first flexible layer 44.

There are several approaches to forming the composite metallic layer 80: (1) using a metal vapor deposition process to deposit a thin metal layer, such as a thin aluminum film, on the surface of

the polymer layer 83; (2) using a pressure laminating process to attach a thin metal film, such as an aluminum foil, to the polymer layer 83; (3) using a die extrusion curtain coating process to coat the polymer layer 83 onto the surface of the aluminum electrically conductive layer 85. The materials used for the polymer layer 83 could include PE, acrylic, PU resin, EVA, or Surlyn™. Depending on the desired flexibility of the composite insulating adhesive tape 40, an alternative impressing process can be performed to mill the polymer layer 83 and the aluminum electrically conductive layer 85 to form a plurality of pores that are randomly distributed throughout both the polymer layer 83 and the aluminum electrically conductive layer 85. Alternatively, only the polymer layer 83 is impressed using the impressing process.

Please refer to Fig.5. A cross-sectional structure of a present invention composite insulating adhesive tape 50, which is able to shield against EMI effects, is depicted. The composite insulating adhesive tape 50 comprises an embossed reinforcing polymer layer 52, a first flexible layer 54, an adhesive layer 56, a release agent coating 59 and an electrically conductive layer 58. Similarly, the embossed reinforcing polymer layer 52 has two faces: a top face 51 and a bottom face 53. The first flexible layer 54 covers the top face 51 of the embossed reinforcing polymer layer 52 by virtue of a conventional a die extrusion curtain coating process. The adhesive layer 56 is formed over the first flexible layer 54.

The differences between the composite insulating adhesive tape 50 in this embodiment and the composite insulating adhesive tape 40 depicted in Fig.4 are that the electrically conductive layer 58 is directly formed onto the bottom face 53 of the embossed reinforcing polymer layer 52. Also, the adhesive layer 56 coats the first flexible layer 54. In general, two conventional methods are used to form the

electrically conductive layer 58: (1) using a metal vapor deposition process to deposit a thin metal layer, such as a thin aluminum film, on the bottom face 53 of the embossed reinforcing polymer layer 52; (2) using a pressure laminating process and applying heat to attach a thin metal film, such as an aluminum foil, to the embossed reinforcing polymer layer 52. Subsequently, the release agent coating 59 is formed over the electrically conductive layer 58 using conventional coating techniques, such as a gravure coater or a wired bar. Either silicon-based, or non-silicon-based, release agents may be used for the release agent coating 59.

Similarly, the embossed reinforcing polymer layer 52 is previously impressed using an impressing process to form a plurality of pores that are randomly distributed throughout the embossed reinforcing polymer layer 52 so as to enhance the flexibility and tearing characteristics of the insulating adhesive tape 50. In one case, the first flexible layer 54 and the embossed reinforcing polymer layer 52 are impressed using the impressing process. After the impressing process, the electrically conductive layer 58 is formed on the bottom face 53 of the embossed reinforcing polymer layer 52. Thereafter, the release agent coating 59 is formed over the electrically conductive layer 58 using conventional coating techniques, such as a gravure coater or a wired bar.

Please refer to table 1. Table 1 is a comparison of the breakdown voltages test of composite insulating adhesive tapes with different thicknesses according to the present invention. The experimental data (breakdown voltage) listed in the right column of table 1 are obtained according to the ASTM 256 standard method, with PE as the starting flexible material over the embossed reinforcing polymer layer. A composite insulating tape that consists of a impressed PET layer with a thickness of 9 μm and a PE flexible layer with a thickness of 20

μm has a test breakdown voltage of 6.0kV, which exceeds that of the required specification of the regular PVC insulating tape by 1.0 kV. The total thickness, however, of the composite insulating tape (29 μm) is only 1/4 to 1/5 of the prior art PVC insulating tape. As the thickness increases, the breakdown voltage rises. When the thickness of the impressed PET layer is 50 μm, the breakdown voltage of the composite insulating tape according to the present invention achieves a value of 13.0 kV, which is twice that of the breakdown voltage of the prior art PVC insulating tape; yet the total thickness is about 1/2 that of the prior art PVC insulating tape.

In contrast to the prior art insulating adhesive tapes, the present invention composite insulating adhesive tape has superior insulation properties and voltage resistance. The present invention uses halogen-free polymer materials, such as PE and PET, as the starting material so that it has little impact on the environment. The embossed reinforcing polymer layer is impressed using an impressing process that enables the composite insulating adhesive tape to be easily torn. In addition, the pores randomly distributed throughout the embossed reinforcing polymer layer, the first flexible layer and the second flexible layer, significantly enhance the flexibility and conformity of the composite insulating adhesive tape. Hence, the adhesive layer of the composite insulating adhesive tape can tightly adhere to an object.

Furthermore, the composite insulating adhesive tape comprising a composite metallic layer can be used to smoothly and tightly wrap a wire or an electrically conductive object so as to prevent EMI effects. Since the thickness of the composite insulating adhesive tape according to the present invention is much less than that of the prior art PVC insulating adhesive tape at the same breakdown voltage, production costs are reduced.

Those skilled in the art will readily observe that numerous modifications and alterations of the device may be made while retaining the teachings of the invention. Accordingly, the above disclosure should be construed as limited only by the metes and bounds of the appended claims.